

DESCRIPTION OF THREE NEW BARNACLES OF THE GENUS *ELMINIUS* (CIRRIPIEDIA : THORACICA) FROM SOUTH AUSTRALIA, WITH A KEY TO SPECIES OF THE ELMINIINAE

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Summary

BAYLISS, D. E. (1994) Description of three new barnacles of the genus *Elminius* (Cirripectida : Thoracica) from South Australia, with a key to the Elminiinae. *Trans. R. Soc. S. Aust.* 118(2), 115-124, 31 May, 1994.

Three new species of intertidal barnacles from South Australia are described. *Elminius flindersi* sp. nov. is a comparatively large species, grey to white in colour which favours habitats with strong water movement although not direct wave action. It has a long hatchet shaped tergum with a centrally localised fold. In comparison with congeners the shell is strong and the cirri are broad and robust. *E. placidus* sp. nov. is a smaller and more fragile species found in very sheltered localities, including mangroves in the Spencer Gulf. It can be distinguished by its banded shell and wedge-shaped tergum. The body and cirri are very elongated. *E. erubescens* sp. nov. is common in the high intertidal zone in the Adelaide region. It is easily distinguished by the reddish coloration of its translucent shell which gives a dark purple appearance on rock.

It is suggested that South Australia has Elminiinae distinct from those of the Eastern States of Australia.

KEY WORDS: Cirripectida, *Elminius flindersi* sp. nov., *Elminius placidus* sp. nov., *Elminius erubescens* sp. nov., *Elminius modestus*, *Elminius adalaidae*, *Elminius covertus*, intertidal, South Australia, taxonomy.

Introduction

In South Australia barnacles belonging to the genus *Elminius* are highly abundant (Womersley & Edmonds 1958; Hutchings & Recher 1982; Bayliss 1982). Until recently, they were classified as *Elminius modestus* Darwin, as were those found in eastern Australia, Western Australia and New Zealand. This situation arose from the very broad definition of this species obtained from a combined examination of Darwin's (1854) original description and illustrations with those of Pope's (1945) paper.

Foster (1980) suggested that Pope's description confused a new species with *E. modestus* as known in New Zealand (Moore 1944; Morton & Miller 1968; Foster 1978) and that Darwin's original material may also have been a combination of these two species. The new species, *E. covertus*, was subsequently described by Foster (1982) together with a six-plated barnacle, *Hexaminus popeiana*. A new subfamily, Elminiinae, was proposed to accommodate them. Studies of larvae by Egan & Anderson (1985) support the establishment of this subfamily.

Foster (1982) furthermore suggested that *E. modestus* was a New Zealand species which had been introduced into Australia by fouling on shipping, probably in the nineteenth century; *E. covertus* was, therefore, the only known endemic Australian species. Bayliss (1988) described another species, *E. adalaidae*, which is abundant in the Adelaide region, and suggested that

E. covertus was not found in South Australia although *E. modestus* was present. Jones (1990) has identified both *E. covertus* and *E. modestus* from southern Western Australia.

There is little fossil material, but Buckeridge (1982) has described *E. chapronierei* from the lower Miocene in Victoria and *E. pomahakensis* from the upper Oligocene in New Zealand (Buckeridge 1984) and suggested the subfamily originated in south-east Australia. He proposed a two-phased migration from Australia to New Zealand and South America, firstly in the Oligocene for *Elminius* with a spur on the tergum and subsequently, in the Cenozoic, for *Elminius* lacking a spur.

This paper describes three new species of *Elminius* which, with *E. modestus* and *E. adalaidae*, brings to five the number of species of this genus found in South Australia.

Systematics

Suborder Balanomorphia Pilsbry, 1916
Superfamily Balanoidea Leach, 1817
Family Archaeobalanidae Newman and Ross, 1976
Subfamily Elminiinae Foster, 1982
Genus *Elminius* Leach, 1825

Type species *Elminius kingii* Gray, 1831

Elminius flindersi sp. nov.

FIGS 1, 3

Holotype: SAM C4242, on iron pilings of ferry jetty, Penneshaw, Kangaroo Island, South Australia; 35°44'S, 137°57'E; D. Bayliss, 21.vii.1992; dissected (partially).

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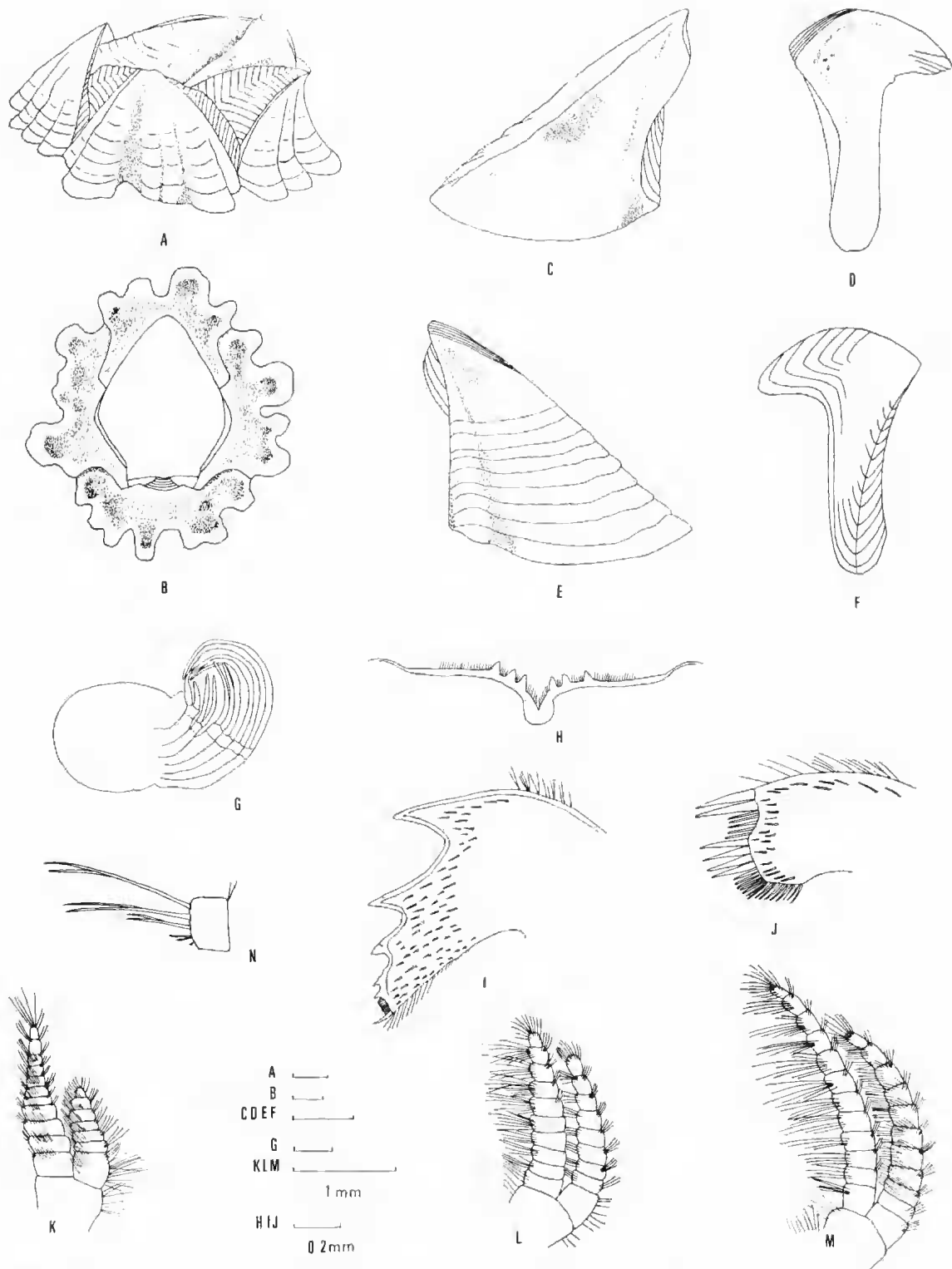


Fig. 1. *Elminius flindersi* sp. nov. holotype. A. External view of shell; B. inner view of shell; C. scutum, internal view; D. tergum, internal view; E. scutum, external view; F. tergum, external view; G. body; H. labrum; I. mandible; J. maxillule; K-M. cirri I-III; N. middle segment, posterior ramus, cirrus VI.

Paratypes: SAM C4243, WAM 727-92; D. Bayliss, 21.vii.1992, same locality as holotype.

Description of holotype: Shell (Figs 1A, 1B): conical, white to grey, opaque. Parieties folded. Orifice pentagonal in outline, width $\frac{1}{4}$ length, carinal sides almost twice as long as lateral sides, rostral side straight. Basal outline sinuous, deeply undulating. Alae wider than radii with less oblique summits. Radii with oblique summits, narrow. Shell 10mm in basal diameter, 9.5mm in width, 4mm in height.

Opercula (Figs 1C, 1D, 1E, 1F): Solid white to grey in colour. Scutum longer than high, basal margin slightly convex with slight upward turning at tergal corner, crests for depressor muscles absent, articular ridge, articular furrow moderately developed, adductor ridge not apparent, adductor pit faint, externally growth ridges present.

Tergum hatchet shaped, vertical articular ridge folding inward to form centrally limited fold, articular margin gently curving in apical region from carinal margin, becoming parallel with basal margin to form long narrow handle, basal margin curving sharply, almost at right angles, to form projection with carinal margin, projection with prominent, deeply carved crests for tergal depressor muscles, spur confluent with basiscutal angle.

Body (Fig. 1G): prosoma white, broad, rounded. Cirri light reddish brown in living specimens, cirri I, II and III slightly darker than cirri IV, V and VI, colour lost on preservation.

Mouthparts (Figs 1H-1J): Labrum with three teeth and setulae, on each side of central notch. Mandible with five teeth, lower short pectinate edge terminating in short curved spine. Maxillule with two large spines above notch, five smaller spines in notch, four large spines below notch, smaller spines at lower angle.

Cirri (Figs 1K-1N): Cirrus I with anterior ramus $\times 1.5$ length of posterior ramus, segments broad, slightly protuberant. Anterior ramus of cirrus II slightly longer than posterior ramus, segments slightly protuberant anteriorly. Cirrus III with anterior ramus slightly longer than posterior ramus, segments slightly protuberant anteriorly; setae on both rami extremely long, stout pectinate setae on six distal segments of posterior ramus. Cirri IV to VI all subequal in length, segments with three large pairs, two small pairs of setae on anterior face, small proximal pair of setae between segments. Number of segments in rami of cirri I-VI shown in Table 1.

Penis: Penis as long as cirrus VI, setose, basidorsal point absent.

Variation: Shell can be tubular, conical or flattened. Parieties can be smooth or undulating with variable number of longitudinal folds. Maximum basal diameter 17mm. Colour varies from white to light grey.

Etymology: The species name refers to the Flindersian biogeographic region.

Comparison with other species: *Elminius flindersi* is larger and more robust than other members of the genus found in Australia. The shell is thicker and comparatively strong. The opercular plates are opaque rather than translucent. The body is broad and rounded with broad cirri.

E. flindersi cannot be reliably distinguished from *E. modestus* on the basis of external shell appearance. The opercular plates are, however, quite different. The tergum (Fig. 1D, 1F) is hatchet shaped with a long handle and an articular furrow which is restricted to the central portion.

E. modestus (Fig. 2B, 2D) has a deep articular fold running from the apical end to almost the basiscutal angle. The articular margin, unless worn, is straight. The scutum (Fig. 2C) has a grey band, but this feature is not always apparent.

TABLE 1. Cirral counts: *Elminius flindersi* sp. nov. (anterior ramus first).

Basal diameter (mm)	Cirrus					
	I	II	III	IV	V	VI
10.0 (holotype)	11,7	10,9	12,11	22,20	24,25	26,27
5.0	12,6	10,1	12,11	18,17	21,20	23,22
8.0	12,7	11,11	13,13	21,20	23,24	26,25
8.0	12,7	10,9	13,13	23,23	27,27	27,28
10.0	11,7	11,10	13,11	22,19	24,23	23,23

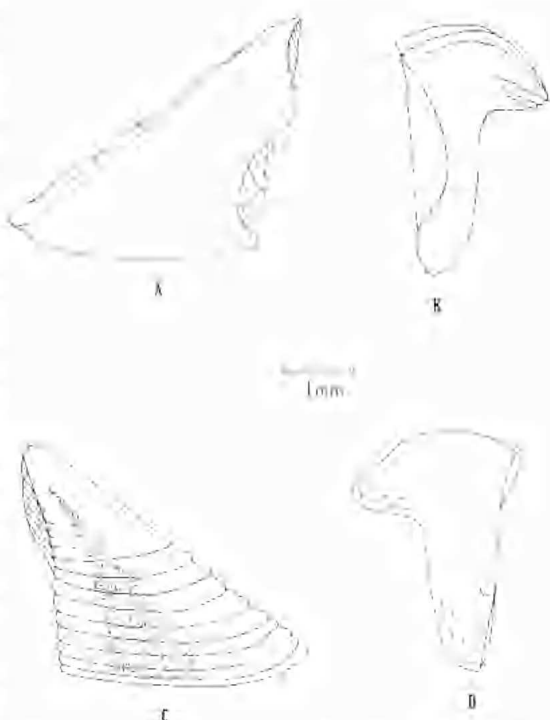


Fig. 2. *Elminius modestus* Darwin. A. scutum, internal view; B. tergum, internal view; C. scutum, external view; D. tergum, external view.

E. modestus also can be distinguished from other members of the genus in lacking pectinate setae on the posterior ramus of cirrus III. The opercular flaps are pure white with a grey band at the rostral end and a small orange dot centrally. *E. flindersi* has a dark brown band at the rostral end and another brown band ventrally on flaps which are dull white.

E. adalaidae (Bayliss 1988 Fig. 2B) has a very small articular furrow, which may not be visible if the tergum is viewed directly from above. The shell is much thinner, translucent, and is light brown. The opercular flaps are, however, too close to *E. flindersi* in appearance to be useful for identification.

Habitat: *Elminius flindersi* is found in the intertidal zone in waters sheltered from direct wave action. It is found in habitats with stronger water flow and more turbulence than other members of the genus in South Australia. In the gulf regions, where wave impact is diminished, it occurs on exposed rocks. It grows in

large sizes on jetties although it is not found on surfaces facing directly into waves at more exposed localities. Outside the gulf regions it is found in habitats protected from oceanic waves such as in boat enclosures behind breakwaters.

Settlement occurs on a wide variety of surfaces including rocks, cement, wood, metal and plastic. It is rarely found in mangroves where water flow is gentle. At Port Pirie it can be found on rocks in the strongly-flowing sections of the tidal river, but not in nearby mangroves.

Distribution: *Elminius flindersi* is widespread in South Australia from Kangaroo Island to Ceduna and the western Eyre Peninsula, and occurs in both gulfs (Fig. 3). In the Spencer Gulf it can be found at Port Augusta indicating that it can tolerate the wide salinity and temperature range found in South Australian waters.

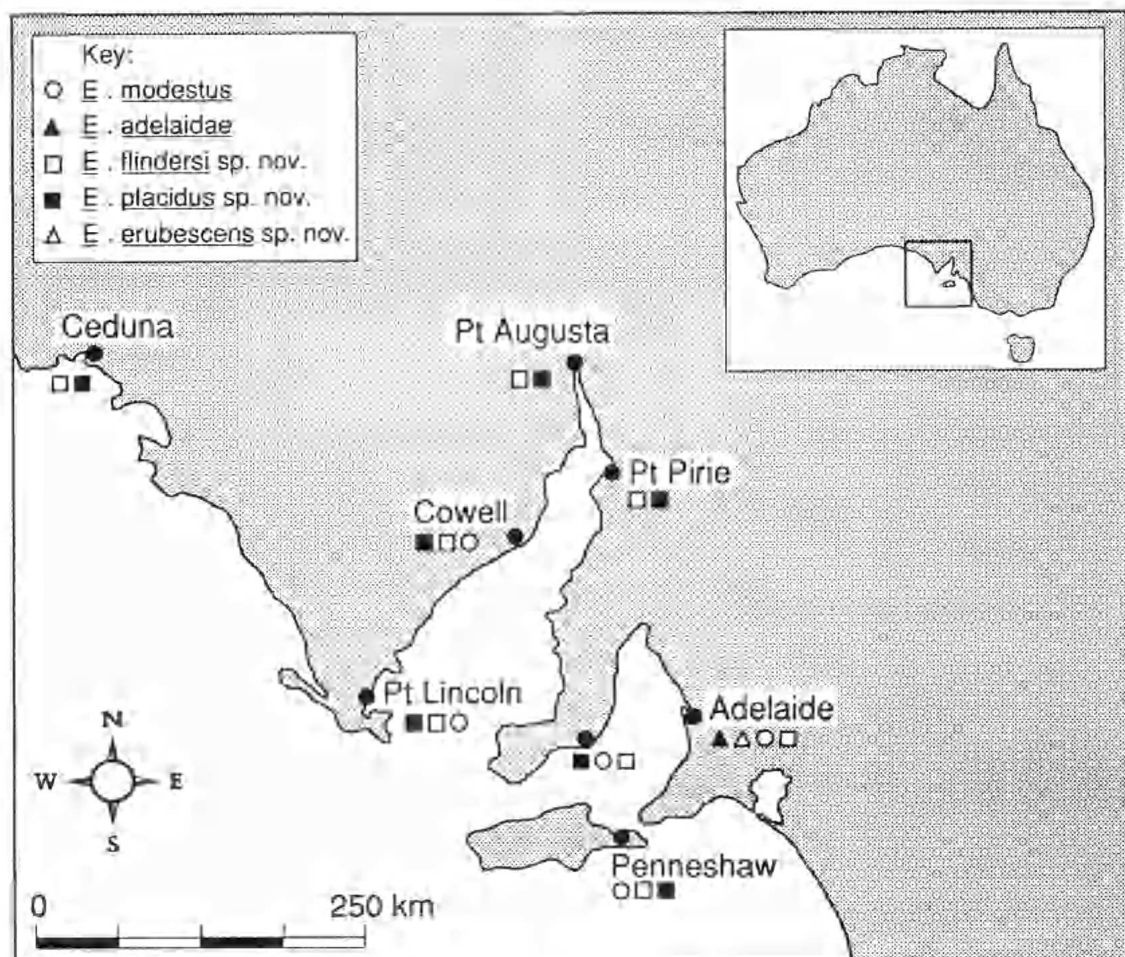


Fig. 3. Distribution of *Elminius modestus* Darwin, *Elminius adalaidae* Bayliss, *Elminius flindersi* sp. nov., *Elminius placidus* sp. nov. and *Elminius erubescens* sp. nov. in South Australia.

Elminius placidus sp. nov.

FIGS 3, 4

Elminius modestus: Womersley & Edmonds 1958: 243, Thomas & Edmonds 1979: 161, Hutchings & Recher 1982: 95.

Holotype: SAM C4244, on branches of *Avicennia marina* at Cowell, South Australia, 33°68'S, 136°94'E; D. Bayliss, 6.ii.1992; dissected (partially).

Paratypes: SAM C4245, WAM 728-92, D. Bayliss, 6.ii.1992, same locality as holotype.

Description of holotype: Shell (Fig. 4A, 4B): upright conical, grey to white with thin brown and dark grey bands parallel to base. Parieties gently folded. Shell thin and nearly translucent. Orifice large, pentagonal in outline, rostral side concave and broad, carinal sides longer than lateral sides, width $\frac{3}{4}$ length. Basal outline sinuous. Alae wider than radii with less oblique summits. Radii with oblique summits, narrow; radii and alae with prominent growth lines. Shell 7 mm in basal diameter, 5 mm in width, 5 mm in height.

Opercula (Figs 4B-E): thin, translucent, white in colour, grey margin near articulating margins of internal surfaces of tergum and scutum. Scutum longer than high, basal margin slightly convex with prominent depression for depressor muscles, no crests apparent, articular ridge, articular furrow moderately developed, adductor ridge, adductor pit not apparent, externally growth ridges present.

Tergum wedge shaped, articular margin and basal margin gently curving from apical end, converging on basiscutal angle, articular furrow shallow, apical portion large with small, feeble crests for tergal depressor muscles; spur confluent with basiscutal angle.

Body (Fig. 4G): Prosoma white, narrow, elongated, palps and cirri I to III very dark brown, cirri IV to VI light brown with dark brown pigment along anterior face of segments, cirrus I covering oral cone.

Mouthparts (Figs 4H-J): Labrum with three teeth and setulae on each side of central notch. Mandible with five teeth, lower pectinate edge terminating in short curved spine. Maxillule with two large spines above notch, five smaller spines in notch, four large spines below notch, smaller spines at lower angle.

Cirri (Figs 4K-N): Cirrus I with anterior ramus $\times 1.7$ length of posterior ramus, anterior ramus with broad proximal segments, narrow distal segments, with long setae, segments slightly protuberant. Anterior ramus of cirrus II slightly longer than posterior ramus, segments slightly protuberant anteriorly. Cirrus III with anterior ramus $\times 1.25$ length of posterior ramus, segments slightly protuberant anteriorly, setae on rami very long, stout pectinate setae on six distal segments of posterior ramus. Cirri IV to VI all subequal in length, segment with four large pairs, two small pairs of setae on anterior face, small proximal pair of setae between segments, anterior face with dark brown

pigment. Number of segments in rami of cirri I to VI shown in Table 2.

TABLE 2. Cirral counts: *Elminius placidus* sp. nov. (anterior ramus first).

Basal diameter (mm)	I	II	III	IV	V	VI
7.0 (holotype)	14,8	10,10	13,13	27,24	28,30	32,30
4.0	14,6	9,9	12,12	24,21	26,25	31,29
4.0	12,6	10,10	11,11	24,23	26,24	30,26
5.0	14,7	10,9	14,13	23,23	27,27	29,27
6.0	14,8	10,10	14,13	25,24	28,23	28,27

Penis: Penis as long as cirrus VI, setose, basidorsal point absent.

Variation: Shell is usually upright conical or tubular and rarely flattened. Shell may have visible banding, but $\times 10$ magnification is often required to see the dark and light bands. On mangroves the barnacles may appear solidly grey. Some specimens collected from rocks have dark grey bands and the shell may appear almost bluish. Thomas & Edmonds (1979) described the shell as being 'bluish-green'. Some specimens have a slight pink tinge towards the top of the parietes.

The tergum is extremely thin near the basal margin and wear may alter the shape. In some specimens the tergum is virtually triangular with the basal margin very gently curving from the tergal crests to the basiscutal angle. On unworn specimens, the external surface of the tergum is grey with a white area at the apical end.

The scutum in many specimens has a nearly straight basal margin and the articular margin is almost at right angles forming a right angle triangle shape. The depression for the depressor muscle is usually well formed with the shell being extremely thin in this area.

Etymology: The species name is derived from the Latin *placidus* meaning calm, tranquil with reference to the habitat of this species.

Comparison with other species: The shell is thin and translucent with narrow dark bands. Other species are uniform in colour and lack the alternating light and dark banding. The opercular plates are thin with grey margins internally along the articulating margins.

The tergum is distinctive in shape. The apical region is large with very feeble crests. The articular margin and the basal margin curve gently to the basiscutal angle forming a triangular or wedge shape.

The prosoma is narrow and elongated as are the cirri. The dark colour of the cirri contrasts with the white prosoma. The coloration survives preservation.

The opercular flaps are cream with a dark black band at the rostral end and another black band centrally. This enables it to be distinguished from *E. modestus*, but it cannot be readily distinguished from other South Australian species which have the same pattern of dark bands on lighter coloured flaps.

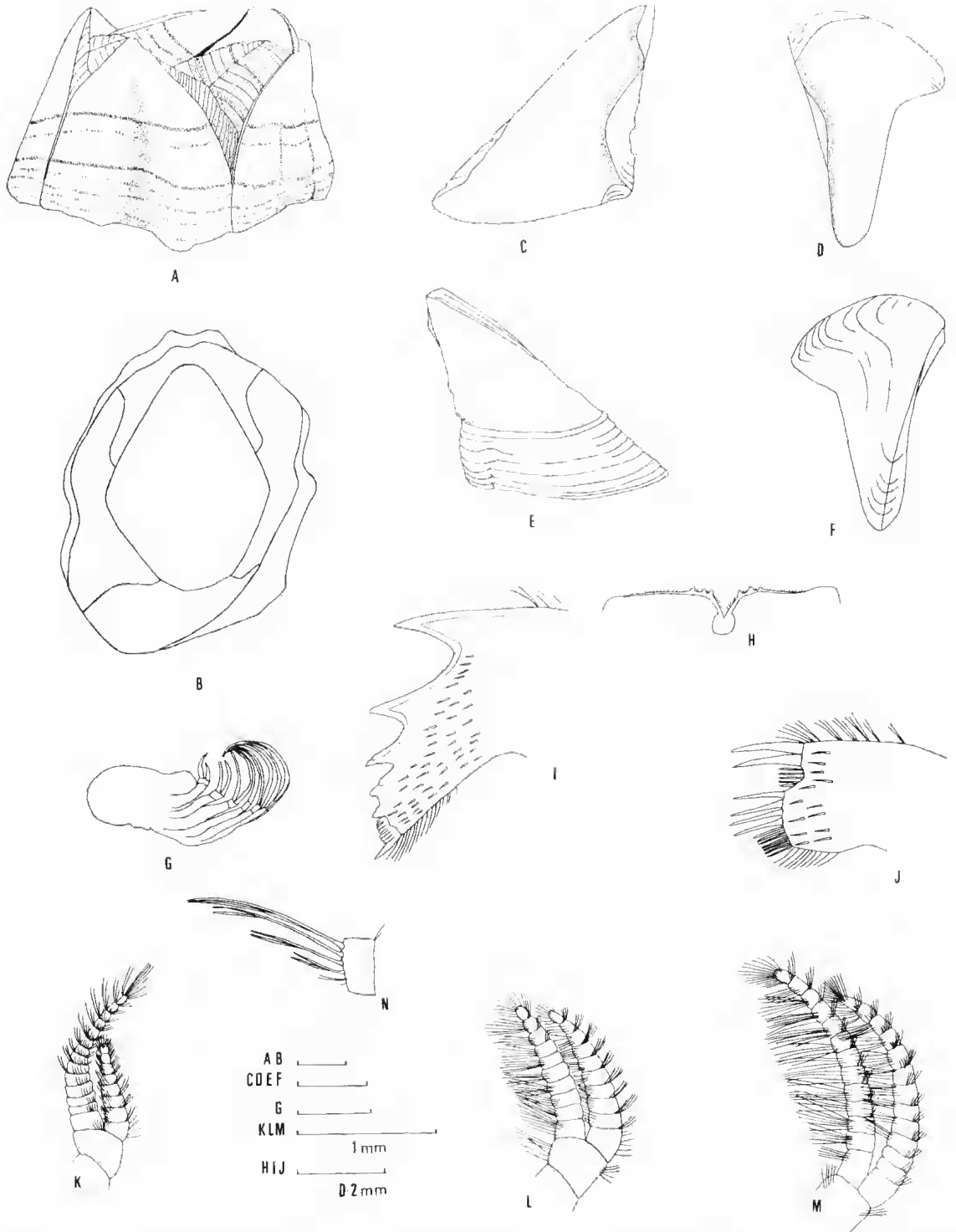


Fig. 4. *Elminius placidus* sp. nov. holotype. A. External view of shell; B. inner view of shell; C. scutum, internal view; D. tergum, internal view; E. scutum, external view; F. tergum, external view; G. body; H. labrum; I. mandible; J. maxillule; K-M. cirri I-III; N. middle segment, posterior ramus, cirrus VI.

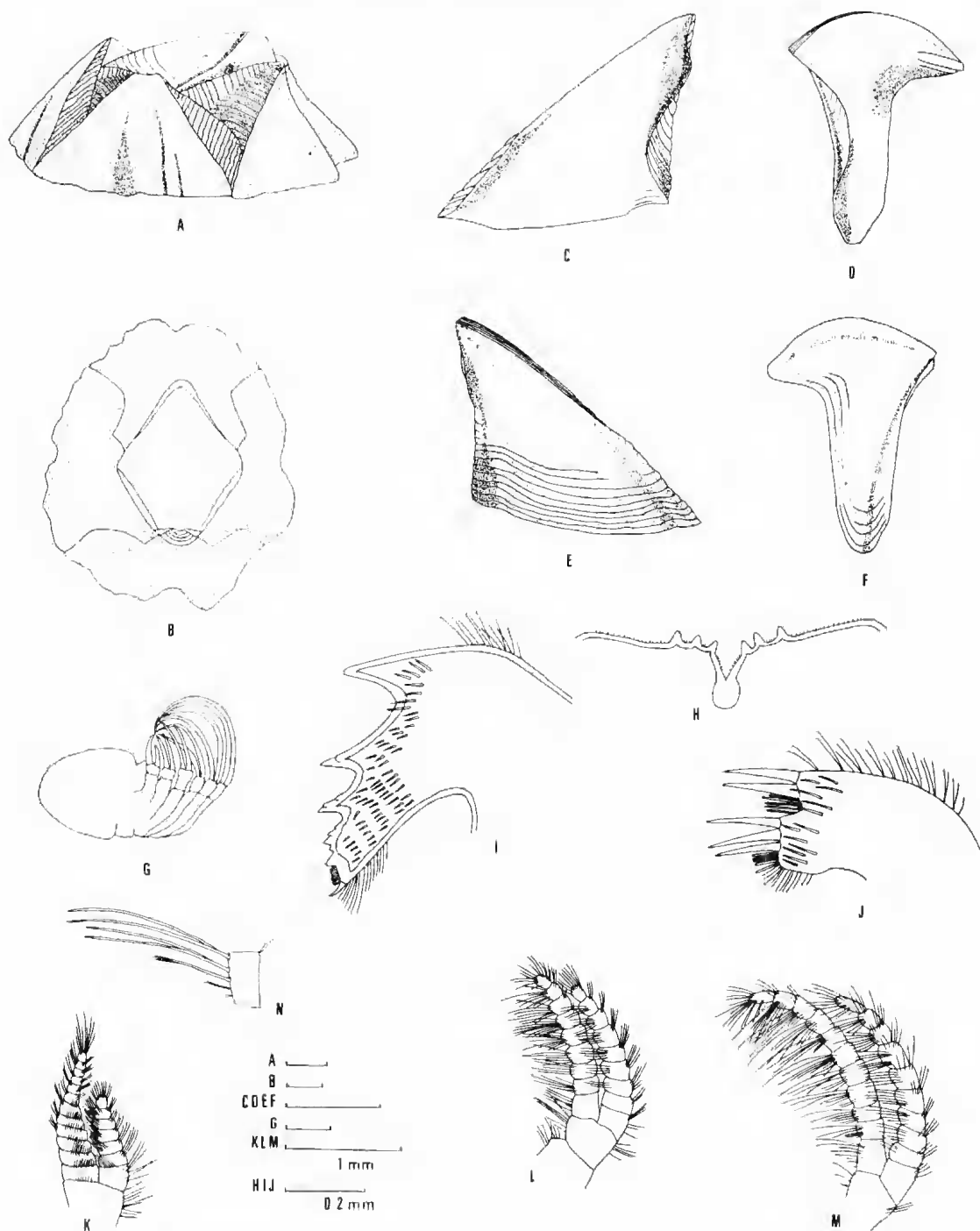


Fig. 5. *Elminius erubescens* sp. nov. holotype. A. External view of shell; B. inner view of shell; C. scutum, internal view; D. tergum, internal view; E. scutum, external view; F. tergum, external view; G. body; H. labrum; I. mandible; J. maxillule; K-M. cirri I-III; N. middle segment, posterior ramus, cirrus VI.

Habitat: *Elminius placidus* is an intertidal species which is found in sheltered habitats. It is highly abundant in mangroves in Spencer Gulf. It settles on branches and pneumatophores, but is rarely found on leaves. It is not restricted to mangroves but also settles on rocks, cement, wood, metal and other surfaces.

Distribution: *Elminius placidus* is widespread, being found on Kangaroo Island, Yorke Peninsula, Spencer Gulf and Eyre Peninsula (Fig. 3). It is not found in the mangroves north of Adelaide which are occupied by *E. adelaidae*.

***Elminius erubescens* sp. nov.**
FIGS 3, 5

Elminius covertus Foster 1982: 26.

Holotype: SAM C4246, collected on rubber tyres at Glenelg boat ramp, Adelaide, South Australia, 34°56'S, 138°36'E, D. Bayliss, 19.vi.1991, dissected (partially).

Paratypes: SAM C4247, WAM 729-92, D. Bayliss, 19.vi.1991, from the same locality as holotype.

Description of the holotype: Shell (Figs 5A, 5B): flattened conical, translucent with red coloration, appearing dark purple before the body removed, colour greyish purple when preserved. Parieties gently folded. Orifice small, pentagonal in outline, width $\frac{1}{4}$ length, rostral side short and straight, other sides almost equal in length. Basal outline sinuous. Alae wider than radii, with less oblique summits. Radii with oblique summits, narrow. Shell 8mm in basal diameter, 7mm in width, 3mm in height.

Opercula (Figs 5C-F): Thin translucent, reddish, greyish purple with white areas when preserved. Scutum longer than high, basal margin slightly convex with upward turning at tergal corner, articular ridge, articular furrow moderately developed, apex reflected outwards, externally growth ridges apparent.

Tergum with articular ridge folding inwards to form well developed furrow, articular margin concave, basal margin curving sharply to form projection with carinal margin, well developed crests for tergal depressor muscles, spur confluent with basiscutal angle.

Body (Fig. 5G): Prosoma light brown, palps and cirri I and II with some dark brown pigment, cirri III to VI clear, partially light brown, preserved material with body and cirri almost uniformly light brown, prosoma and cirri elongated, cirrus I overlapping oral cone.

Mouthparts (Figs 5H-J): Labrum with three teeth and setulae on each side of central notch. Mandible with five teeth, lower short pectinate edge terminating in short curved spine. Maxillule with two large spines below notch, smaller spines at lower angle.

Cirri (Figs 5K-N): Cirrus I with anterior ramus $\times 1.5$ length of posterior ramus, segments slightly protuberant. Anterior ramus of cirrus II slightly longer

than posterior ramus, segments slightly protuberant anteriorly. Cirrus III with anterior ramus slightly longer than posterior ramus, segments slightly protuberant anteriorly; setae on both rami long, stout pectinate setae on six distal segments of posterior ramus. Cirrus IV to VI subequal in length, segments with three large pairs, two small pairs of setae on anterior face, small proximal pair of setae between segments. Number of segments in rami of cirri I to VI shown in Table 3.

TABLE 3. Cirral counts: *Elminius erubescens* sp. nov. (anterior ramus first).

Basal diameter (mm)	Cirrus					
	I	II	III	IV	V	VI
8.0 (holotype)	12,7	9,9	11,10	21,24	25,24	28,30
7.0	14,6	9,9	12,12	25,28	29,27	32,31
7.0	15,6	10,8	11,11	23,20	25,24	25,24
7.5	13,6	11,10	12,11	20,19	23,23	25,25
9.0	12,6	9,9	13,12	23,23	25,26	30,27

Penis: Penis as long as cirrus VI, setose, basidorsal point absent.

Variation: *Elminius erubescens* is usually flattened although tubular and upright conical forms can occur. The shell often has broad longitudinal folds which vary in number between specimens. Maximum basal diameter 12mm.

Etymology: The specific name is derived from the Latin *erubescere*, to blush with modesty, in reference to its redness.

Comparison with other species: *Elminius erubescens* can be easily distinguished from other species in South Australia by the red coloration of the translucent shell which, in the field, appears dark purple. The shell is otherwise close to *E. modestus*. It lacks the ridges seen in *E. covertus*, although worn specimens of the two species are similar in appearance. The tergoscute flaps are straw to pale yellow with two dark brown to black bands. A small portion of the flaps between the rostral end and the first dark band are white. *E. covertus* has six pairs of dark spots on white tergoscute flaps.

Habitat: *Elminius erubescens* is common in sheltered waters in the Adelaide region although it is not found in mangroves. It settles on a wide variety of surfaces including rock, cement, wood, metal and rubber. It is the highest barnacle in the intertidal zone. There is little overlap with *E. modestus* which forms a zone below it. On rocks it is usually found on surfaces which are overlapping or do not face directly into the afternoon sun, although it can stand exposure to sunlight for part of the day. *E. adelaidae* avoids sunlight and is found under rocks which are lower in the intertidal zone.

Distribution: This species is very common in the Adelaide region, but was not found elsewhere in South Australia (Fig. 3). Its distribution outside of South Australia is unknown.

Key to species of the Elminiinae

- 1 Shell with four compartmental plates 2
Shell with six compartmental plates 6
- 2 Tergum with spur confluent with basiscutal angle 3
Tergum with distinct spur *Elminius kingii* Gray (South America)
- 3 Shell white or grey 4
Shell not white or grey 5
- 4 Shell white; tergum with straight articular margin, deep articular furrow *Elminius modestus* Darwin (Australia, New Zealand, Europe, South Africa)
- Shell greyish-white, tergum hatchet shaped, concave articular margin, centrally localised furrow *Elminius flindersi* sp. nov. (South Australia)
- Shell grey, narrow dark bands alternating with white, tergum wedge shaped, weak crests, shallow furrow *Elminius placidus* sp. nov. (South Australia)
- 5 Shell light brown, tergum with small furrow restricted to apical end *Elminius adelaidae* Bayliss (South Australia)
- Shell translucent with red coloration, purple in field, tergum with concave articular margin, deep furrow *Elminius erubescens* sp. nov. (South Australia)
- Shell buff red with cream ridges, tergum hatchet shaped *Elminius covertus* Foster (NSW, Western Australia)
- 6 Shell pale brown with reddish brown bands between low ribs, tergum with spur longer than basiscutal angle *Hexaminius foliorum* Anderson, Anderson & Egan (NSW)
- Shell greyish cream with darker radial bands, tergum with spur not longer than basiscutal angle *Hexaminius popeiana* Foster (NSW)

Discussion

The diversity of extant species, as well as fossil evidence, suggests that the Elminiinae originated in south-eastern Australia (Buckeridge 1982, 1984). The species present in South Australia are, with the exception of *Elminius modestus*, not found in NSW. The genus *Hexaminius* is not represented in South Australia and *Elminius covertus* is also absent.

South Australian barnacle populations are geographically isolated from the eastern States by a long expanse of coastline, from Robe to Cape Otway in Victoria, in which intertidal species are virtually absent (Womersley & Edmonds 1958). In South Australia there are extensive areas of coastline which are protected from oceanic waves in the gulfs which contain ideal habitats for *Elminius*. Speciation may have occurred in the variety of sheltered habitats which are available.

It is also possible that species from elsewhere along the southern coastline of Australia have been introduced. At present the distribution of *Elminius* species in other States has not been determined. The presence of *E. covertus* in Western Australia (Foster 1982) has been confirmed by Jones (1990). It is possible that it was introduced from eastern Australia. *E. modestus* may have been introduced from New Zealand (Foster 1982; Flowerdew 1984), but an electrophoretic comparison involving South Australian forms has yet to be done.

At present there is a large scale attempt to establish an oyster industry in South Australia using spat from Tasmania. This could lead to introductions of species not endemic to South Australia.

Two species of *Elminius* are extremely abundant in mangroves in South Australia, but their distributions do not overlap. *E. adelaidae* is found in the mangroves north of Adelaide whereas *E. placidus* is found in mangroves in the Spencer Gulf. The two gulfs have considerable differences in their marine invertebrate fauna (Shepherd 1983).

Only *E. adelaidae* utilises the leaves as well as the branches and pneumatophores. Anderson *et al.* (1988) have described a species *Hexaminius foliorum*, which is specialised for living on leaves. The adaptations they list as important for this species, which include thin shell, thick basal membrane, long elongated cirri and rapid cirral beating, are also found in *E. adelaidae*. Nevertheless, *E. adelaidae* grows to a much larger size, is found in other habitats and has a larger variety of cirral beating patterns, including the ability to hold the cirral fan fully extended. *E. placidus* has a more restricted range of cirral activity and lacks the ability to beat rapidly. The basal membrane is also thinner. Its thin shell and elongated body suggest a species adapted for very calm habitats, but not necessarily mangroves.

In New Zealand *E. modestus* is reported to live in mangroves (Moore 1944; Morton & Miller 1968). The present author has observed several spatfalls in mangroves near Adelaide, but they failed to persist. It is uncommon for *E. flindersi* to be found in mangroves and no *E. erubescens* were found in mangroves despite its abundance on rocks in the Adelaide region.

Acknowledgments

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